The American Biology Teacher

MAY, 1955 VOL. 17, NO. 5

Drosophila Experiments

The Sunflower

Marine Biology

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COVER PHOTOGRAPH

Robin feeding young at nest in evergreen tree. From an Ektachrome transparency taken by John Stemen, Goshen, Indiana, who is field auditor for the State of Indiana and enjoys nature photography as an avocation.

THE AMERICAN BIOLOGY TEACHER

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Drosophila Experiments for High School Biology

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The common fruit fly, Drosophila, is an excellent organism to use in demonstrating inheritance. During the course of one semester, several generations of these flies can be obtained. By following proper breeding procedures, it is possible to verify many basic rules of heredity. In addition, students may learn a number of other biological facts and techniques by working with living cultures of these flies.

Drosophila are really very easy to raise. They flourish at ordinary room temperature and complete their life-cycle in about 12 days. They may be anesthetized for handling and sorting. Many types of hereditary variations can be classified with the naked eye. Table I lists easily identified Drosophila types.

New and interesting experiences await the teacher and student as they work with each new characteristic. Breeding experiments may be conducted in which the principles of heredity are disclosed. Histological studies will reveal the ontogeny of normal and mutant types. Various components of the environment (such as temperature) may be changed to show basic principles of physiology and ecology.

Handling Flies

Flies can be anesthetized for examination and transfer. An ether chamber for this purpose may be made using the same type of bottle in which the stocks are kept. Stopper the bottle with a tight fitting cork to which has been attached a bit of cotton or other absorbent material. A few drops of ether on the cotton is sufficient to fill the chamber with fumes.

To remove the flies from a rearing bottle, tap bottle gently on table top to dislodge flies from the cap end of the bottle. Quickly remove cap and place ether chamber over open bottle. Invert bottle and chamber together and shake flies into chamber by tapping on palm of hand. Quickly close the chamber with the cork and ether soaked cotton. Practice this several times with an empty bottle before attempting to do it with live flies.

TABLE I

Hereditary traits in Drosophila which may be identified with the naked eye. (Wild-type, +, is always dominant except with Bar. All other genes are recessive.)

	Symbol	Name	Description
Wing types:	+	Wild-type	Normal wing
	vg	vestigial	wing reduced to stub
	m	miniature	wing half-size (sex-linked)
	c	curved	wing curved down
	cu	curled	wing curved up
	ho	held-out	wings spread
	rsd	raised	wings held erect
	tx	taxi	wings divergent
Body colors:	+	wild-type	tan-gray color with black accents
	e	ebony	black body
	y	yellow	light yellow body (sex linked)
Eye types:	+	wild-type	red eye color
	w	white	colorless eye (sex-linked)
	se	sepia	dark brown eye, almost black
	cl	clot	dark brown eye
	B	Bar	eye reduced to narrow stripe (sex-linked)
	ey	eyeless	eye reduced to small dot

Preparation of Drosophila Media

The following recipe will make enough media for about 30 rearing bottles (½ pint cream bottles).

Water	1000 cc.
Agar	18 gm.
Corn Meal	60 gm.
Dry Yeast	10 gm.
Drosophila mix*	50 gm.
Propionic Acid**	5 cc.
Methyl Parasept** (12.5% soln. in alcohol)	12 cc.

Mix agar, water, and corn meal and cook 10-15 minutes, stirring frequently. Add extra water if too thick. Add Drosophila mix and cook at a slow boil for 2 minutes longer. Cool 5 minutes and stir in propionic acid and methyl parasept. Pour to a depth of about 1 inch in clean rearing bottles being careful not to let food run down sides of bottle. Cap the bottles immediately to prevent stray flies from entering and depositing eggs. Bottles may be stored at room temperature but should be protected from heat or extremely dry conditions.

*Drosophila mix may be made up in advance and kept on shelf, as follows:

Sugar (Sucrose)	300 gm.
$NaNO_3$	30 gm.
K_2HPO_4	10 gm.
$MgSO_4$	5 gm.
KCl	5 gm.
$FeSO_4$	0.1 gm.

**Mold and bacteria inhibitors. Methyl Parasept may be obtained from Heyden Chemical Corp., 393 Seventh Ave., New York 1, N. Y.

The flies will succumb in about 10 seconds after they encounter the ether fumes. When all flies are motionless (after about 15 seconds), remove the cork and pour flies on a clean 3 x 5 white card for sorting and examination. If flies are allowed to remain in the etherizer too long, their wings bend upward, their bodies curl and they die.

Etherized flies will recover in about 5 minutes. Sorting and examining, therefore, must be done rapidly and with small lots of flies. Flies are usually rendered sterile by etherizing a second time.

Sorting can be done with a pocket knife or sharp dissecting needle. String the flies along the card in a thin line and sort from right to left (if you are right handed) by sweeping one type toward the top of the card and another toward the bottom.

Care should be taken not to overheat the flies with a strong light while examining them. Fluorescent lights should be used if the light source is to be brought close to the flies.

Typical microscope set-up for sorting and counting flies. A less elaborate microscope can be used. With many traits, identification and sorting can be done without the aid of a microscope.

Rearing

Before introducing flies to a fresh food bottle, seed the surface of the food with a few grains of live yeast (small, foil-wrapped packages may be obtained at your grocery store) or a few drops of a suspension of live yeast. The food in the bottle is primarily for growth of yeast, upon which the flies feed. Next, insert a piece of tissue or paper toweling about 2 inches square into the food to provide a dry surface upon which the flies may be dropped. Flies will become stuck and die if dropped on the surface of the moist food.

Rearing bottles must be kept at a temperature no higher than 80 degrees F. and, preferably, above 70 degrees F. They should not be exposed to direct sunlight and may be kept entirely in the dark.

About 5 days after introducing flies to a fresh bottle, small larva may be seen crawling in and over the surface of the food. In about 8 days, pupa will be evident along the edges of the piece of tissue. A new generation of adults will begin to emerge from the pupa cases in about 12 days.

Identification

The easiest way of distinguishing male and female is by reference to the posterior end of the abdomen. The male appears to have a black tipped, blunt posterior end, while the

Wild-type flies. Male above, female below.

Held-out, right, and normal wing types.

female is lighter colored and has a pointed posterior. Looking on the ventral surface, the male genetalia serve as a distinguishing feature.

Obtaining Virgin Females for Studies of Heredity

Select a rearing bottle in which new adults are emerging in considerable numbers (i.e. a culture about 14 days old) and remove *all* adult flies from the bottle and discard or transfer to a new bottle. Make a note of the time when this is done. Return to the bottle in 10-12 hours and remove all adults that have emerged in the interim. The females thus obtained will be virgins and may be used in making crosses. Females older than 12 hours, if they have been with males, should be considered mated. Once mated, a female may not be successfully mated to another male. Pale colored flies with incompletely expanded wings are those which have just recently emerged from the pupa case. These should be avoided in selecting flies for a cross since ether will sterilize flies of this age.

Making a Cross

Select virgin mutant (vg) females and place 2 in each of 3 food bottles. Place with them two wild-type (+) males. Mark the date and the type of mating on the cap. They will mate soon after recovering from the ether and the female will begin to lay eggs in about 36 hours. Thereafter, she will lay about 50 eggs a day. Matings are made in triplicate in order to assure success.

After seven days, remove the parent flies from the mating bottle and discard them. By this time, larva should be evident in considerable numbers.

The Hybrid (F_1's)

About 12 days after the date of the original mating, F_1 flies should begin to emerge. The first flies will be almost all females because they have a slightly shorter developmental time than males. These F_1's should be all wild-type (+) flies. If any mutant (vg) flies emerge at this time it is an indication that the parent female was not virgin.

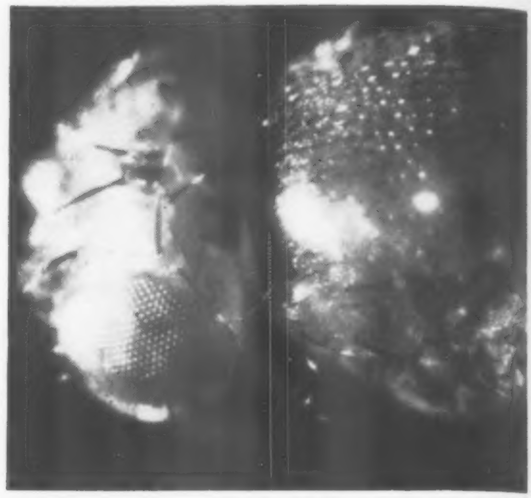
Place about 6 pairs of F_1 flies in each of 3 fresh food bottles (these need not be virgin flies). Mark these with the date, the type of original mating, and the generation. Each of these food bottles will produce about 250 flies in the next generation.

Virgin F_1 females may be obtained and back crossed to mutant males to provide an interesting back cross generation for counting.

The F_2 Generation

The 6 pairs of F_1 flies should be removed from each of the bottles in about 7 days. In the usual length of time, the F_2 generation will begin to emerge. The sex and type of each of the F_2 flies should be determined and recorded. Flies will continue emerging for

Close-up side view of anesthetized female. Notice the curled wings, short blunt bristles, bar eye and white eye color. All these traits are inherited.



Close-up of Drosophila head showing bristle placement. Presence of two large bristles on mid-posterior of head depends on a single hereditary factor.

about 8 days. Countings should be made every other day.

Questions

1. Why are the F_1's all wild-type?
2. Was there any difference in the ratio of mutant types to wild-types in the first count and the third count of the F_2? What about the ratio of males to females in different counts?
3. What is the grand total ratio of mutant types to wild-types?
4. Is a backcross ratio different from an F_2 ratio? Why?
5. Is the ratio of mutant females to wild-type females the same as the ratio of mutant males to wild-type males?
6. Would a mating of wild-type females and mutant males give any different results? (Why not try it?)

Obtaining Pure Cultures

Pure cultures of various Drosophila mutants may be obtained by mail from several different biological supply houses. They cost about $2.75 each. It is also possible to obtain ready-made crosses in large bottles for a slightly higher price.

Once obtained, the pure stocks may be carried on by transferring a few flies to a new media bottle about every three weeks. Stocks may be lost during the summer if provision is not made to keep them cool.

Interesting Projects

1. *Sex-linkage.* Cross Bar female with wild-type male. In F_1, all males will be Bar and all females, wide-Bar (indicating heterozygous B). If wide-Bar F_1 females are crossed to wild-type males, half the male progeny will be Bar and half wild-type; half the females will be wide-Bar and half wild-type.

If the original cross is made with wild-type females and Bar males, the F_1 males are (like their mothers) all wild-type and the F_1 females are all wide-Bar.

This experiment shows the pattern of sex-linked inheritance a little more clearly than one in which a recessive is used. Since the Bar gene is dominant, its presence is never "hidden" in the heterozygous condition.

2. *Autosomal dihybrid inheritance.* Cross a vg female with an e male (or vice versa). The F_1 will be all wild-type and should be mated *inter se* to give and F_2. The F_2 should yield a ratio of 9 wild-types, 3 vg, 3 e, and 1 vg e. It is interesting to take virgin F_1 females and "testcross" mate them to vg e males to show a typical testcross ratio of 1 wild-type, 1 vg, 1 e, and 1 vg e.

3. *Linkage and crossing-over.* Cross ho cl female with a wild-type male and testcross both F_1 females and F_1 males to the ho cl stock. The testcross of F_1 female to ho cl male should give a ratio of about 9 wild-type, 1 ho, 1 cl, 9 ho cl (very different from the ex-

Curled wings, also with bar eye and white eye color.

pectel 1:1:1:1 if these genes were not linked). When the F_1 male is used to testcross to a virgin ho cl female, the progeny are half ho cl and half wild-type, indicating a unique feature of Drosophila inheritance, namely that crossing-over does not take place at all in the male.

4. *Life cycle.* Raise Drosophila at several different temperatures, perhaps near a cold window, near the ceiling, on the floor, and on a table. Have a thermometer near each site to record the temperature. Carefully observe the length of each stage in the life cycle (egg, larva, pupa, adult), and relate this to the temperature. In general, one finds that the life cycle lengthens as the temperature goes down.

Reference

"Drosophila Guide." M. Demerec and B. P. Kaufman. Published by Carnegie Institution of Washington, 1530 P Street Northwest, Washington 5, D. C. and sold for 25 cents a copy.

OHIO SCIENCE FAIR GROUP SOLVES 'HOPPER PROBLEM

ARCHBOLD, Ohio—One way to tackle the grasshopper problem is to serve them French-fried to guests.

This was the tasty treat in store for visitors to the 5th Annual Quadri-County Science Fair held at the high school here (April 8, 9). Described as both "edible and palatable," the hot 'hoppers were whipped up by the Epicures Club as a fair treat.

Last year, the same group of gourmets passed out tasty little tidbits of rattlesnake meat to those who came to view the science exhibits.

Science Service

Special Techniques for Growing Ferns

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The sensitive fern, *Onoclea sensibilis,* has erect fertile stalks that are easy to locate in moist soil during the winter. In this particular fern one may speed the release of the spores by placing the sporophyll heads for one second (in and right out) of boiling water. Then the stalks are dried by laying them on a flat sheet of paper in the laboratory or, if one prefers, into a low temperature (37°C) oven. Within one to two days many of the spores will be released (Fig. 1). One may carefully hold the paper containing the spores at an angle near enough to the vertical to let most of the heavy spore cases fall, while most of the spores will be retained. The spores are placed on the surface of mineral solution (1) in a petri dish; here they will grow in ten days into prothallia which may be used for class

FIGURE 1—The reproductive structures of sensitive fern are sketched from live material under 20X magnification. Drawings by George Mustric, eleventh-art student.

FIGURE 2—To the left is illustrated the method of transferring the prothallia from the surface of a liquid to a more substantial growing medium. *To the right* is a one year old transplant, *Drynaria quercifolia*, East Indies, the spores of which were collected in the Missouri Botanical Gardens, St. Louis. The crock was temporarily removed from the beaker for better photography. Photo by Oliver Cooper.

work or for experimentation. To obtain much further growth, however, the young ferns must be transplanted. A crock of peat moss (Fig. 2) is placed upright in a beaker to which mineral solution is added to a height just above the top of the peat moss. Next this entire growing medium is sterilized. The mineral solution with the prothallia to be transplanted is poured from the petri dish into the growing medium, making the water line just above the top of the crock. The water will gradually lower with evaporation, even though the beaker is covered with glass, so that the young ferns will become sporophytes with the roots growing in the peat moss.

The sensitive fern has spores big enough to be handled easily by the high school student. Locally, though, when full-grown prothallia were obtained by growing them on inverted flower crooks (2), the *Onoclea* in six weeks had an average width of 5 microns. An exotic maidenhair fern, *Adiantum fergusonium*, in three weeks had prothallia with an average width of 6 millimeters. The genus *Adiantum*, maidenhair fern, is furthermore noteworthy in producing prothallia that lie flat on the microscope slide. It is interesting to note that spores of *Adiantum fergusonium*, native of Mexico, were gathered in the national Botanical Gardens, Washington, D. C. *Adiantum Capillus-veneris* (Fig. 3), native throughout southern United States and extending north into the protected ravines of the Black Hills (3), was collected in the Franklin Park Observatory, Columbus, Ohio. Though not native of Ohio, the same species was found growing as a weed under the benches of a greenhouse near London, Ohio. Obviously the effort of gathering a few ripe fronds of ferns and placing them in a sealed envelope may supply material for much study and experimentation in the classroom. On the other hand, for one who prefers prothallia much larger than the Adiantum, he should obtain the climbing fern, *Lygodium japonicum* (4), raise them on the inverted crock, and be careful to water them to the side to avoid fertilization which would end further growth of the prothallia.

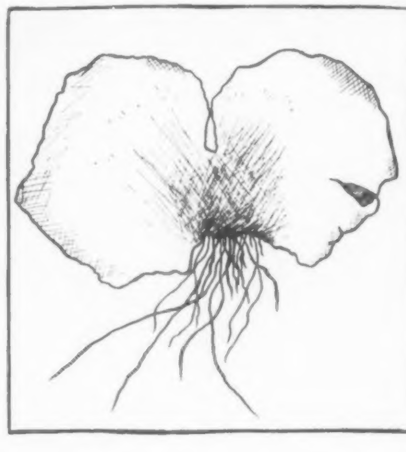

FIGURE 3—Prothallus of *Adiantum Capillus-veneris*.

1. Clarke, Herbert M., Growing Fern Prothallia, *Amer. Biol. Teacher*, Vol. 16 (8): 214-215, 1954.

2. Miller, D. F. and Blaydes, G. W., *Methods and Materials for Teaching Biological Sciences*, McGraw-Hill Book Co., Inc., N.Y.C., 1938, p. 219.

3. Fernald, M. L., "Adiantum Capillus-veneris in the U. S.," *Rhodora*, 52: 620, Aug. 1950, pp. 201-8.

4. Lygodium spores may be purchased from The Ohio Biological Supply Co. which has advertisements in recent issues of ABT.

The Origin and Development of the Cultivated Sunflower[1]

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The origin of cultivated plants has long challenged the imagination of both botanists and anthropologists. The problems relating to the tracing of such origins have been subject to renewed interest and scientific inquiry in recent years (1, 7). The cultivated sunflower is of particular interest because it is one of the few crop plants to have been domesticated in temperate North America and it is one of the few plants whose wild progenitor is definitely known.

The common sunflower, *Helianthus annuus* L., comprises three main races *H. annuus* ssp. *lenticularis*, the "wild" sunflower; *H. annuus* ssp. *annuus*, the "weed" sunflower; and *H. annuus* ssp. *macrocarpus*, the giant sunflower cultivated for its edible seeds. The first, which is widespread in western North America, is a branched sunflower with small heads and achenes and few rays. The weed sunflower is also branched but with larger heads, achenes, and more numerous rays than the wild race. Its distribution is primarily confined to the middle western United States. The cultivated sunflower is generally unbranched and bears a single massive head with numerous rays and quite larger achenes. Its distribution is practically world wide today but it does not persist outside of cultivation.

In his now classic *Origin of Cultivated Plants* de Candolle pointed out that the methods for discovering the origin of cultivated species were to be derived from botany, archaeology and paleontology, history, and philology. In the present paper some of these lines of evidence will be examined in relation to the origin of the cultivated sunflower.

The Use of the Wild Sunflower

Achenes[2] of wild sunflowers were gathered by many Indians of the western United States for use as food, and the plants or flower heads were often used either medicinally or ceremonially. The principal species used for these purposes was the common wild sunflower, *H. annuus* ssp. *lenticularis*. Among the archaeological material from Castle Park, Colorado, a single seed was found which has tentatively been identified as wild *H. annuus*. Several heads of wild sunflowers are found among the archaeological remains from Tularosa Cave, New Mexico, along with maize and other cultivated and wild plants (4).

Observations within historic times have shown that the seeds of wild sunflowers furnished a particularly prized source of food for many groups of Indians of the western United States. The seeds were eaten raw or were more frequently pounded into a sort of flour and made into flat cakes or mixed with other substances. Many of the early explorers, including Lewis and Clark, have left us accounts of the gathering of the achenes and the methods by which they were prepared for eating. Medicinally the plant was used principally as a cure for chest pains. The flowers were worn in the hair in ceremonial dances among the Hopi.

No references to the use of the wild sunflower are reported for locations east of the Mississippi. The area of greatest use of wild sunflowers is shown on figure 1. It is probably somewhere within this area that the species had its origin as a wild plant. It apparently was early adopted as a food plant by certain Indians and its spread as a weed is in all probability the direct result of man's use of the plant. This early use and spread can be viewed as a necessary step toward its eventual domestication.

[1]This article is based largely on two earlier papers (3, 5). Rather complete bibliographies appear in these and only additional titles will be cited here. The study has been supported in part by a grant from the National Science Foundation since 1952.

[2]The fruit of the sunflower is botanically known as an achene and includes the seed proper with the pericarp around it.

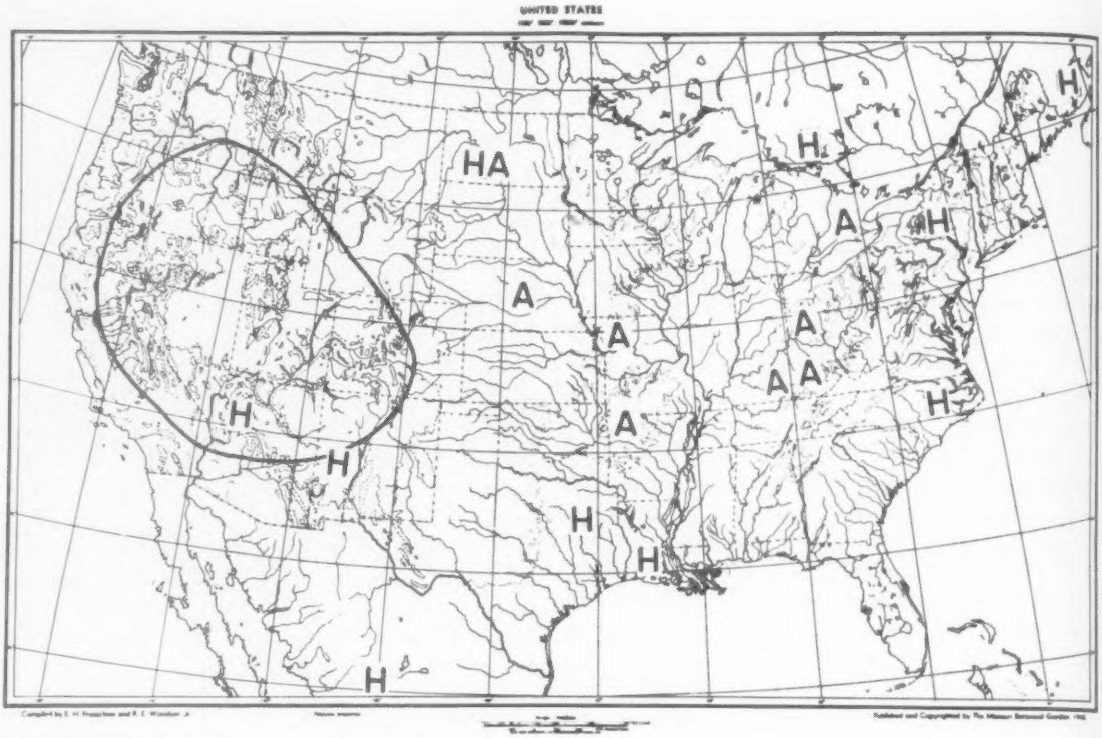

FIGURE 1—Map showing the locations of prehistoric cultivated sunflowers (A), distribution of the cultivated sunflower among the Indians in historical times (H), and the area of the greatest use of the wild sunflower (in heavy line).

FIGURE 2—Comparison of a modern variety of cultivated sunflower, Mammoth Russian (left) with prehistoric achenes from Cramer Village site, Ohio. The latter achenes are charred and are probably 10-15% smaller than the original size.

FIGURE 3—Prehistoric sunflower remains from Newt Kash Hollow Shelter, Kentucky. (Specimens from the University of Kentucky.)

The Prehistoric Distribution of the Cultivated Sunflower

Achenes and heads of sunflowers have been found at a number of archaeological sites in the eastern half of North America (fig. 1.). From the size of these structures we can infer that the Indians of this region had the cultivated sunflower (fig. 2). The achenes recovered at many of the sites are as large as any known for modern sunflowers, so it seems likely that the sunflower was fully developed as a cultivated plant long before the discovery of the New World. The material recovered from Newt Kash Hollow Shelter, Kentucky (6) is of particular interest in that the small size of the heads (fig. 3) and achenes suggests a rather primitive type of the cultivated plant which may represent one of the stages through which the sunflower passed before it reached the single large headed condition. At most of the sites the sunflowers are found with maize, but it is possible that the sunflower was in cultivation before the Indians had maize and the other food plants which originated elsewhere. A fact which may be of considerable significance is that no archaeological cultivated sunflowers have been found in the southwestern area where there was a well developed agriculture in prehistoric times.

The Cultivated Sunflower Among the Indians In the Post Colombian Period

From the accounts of the early explorers it is possible to map roughly the area of cultivation of the sunflower in North America (fig. 1) in early times. Champlain in 1615 observed the sunflower in cultivation in eastern Canada, and it was subsequently observed by others in the northeastern area. In addition to its use for food, the sunflower seed was a source of oil which was used for cooking, annointing the hair, and as a base for various pigments which were painted on the face and body. The mention of the sunflower in the creation myth of the Onondago along with other cultivated plants might indicate long usage of the plant. The plant is still cultivated

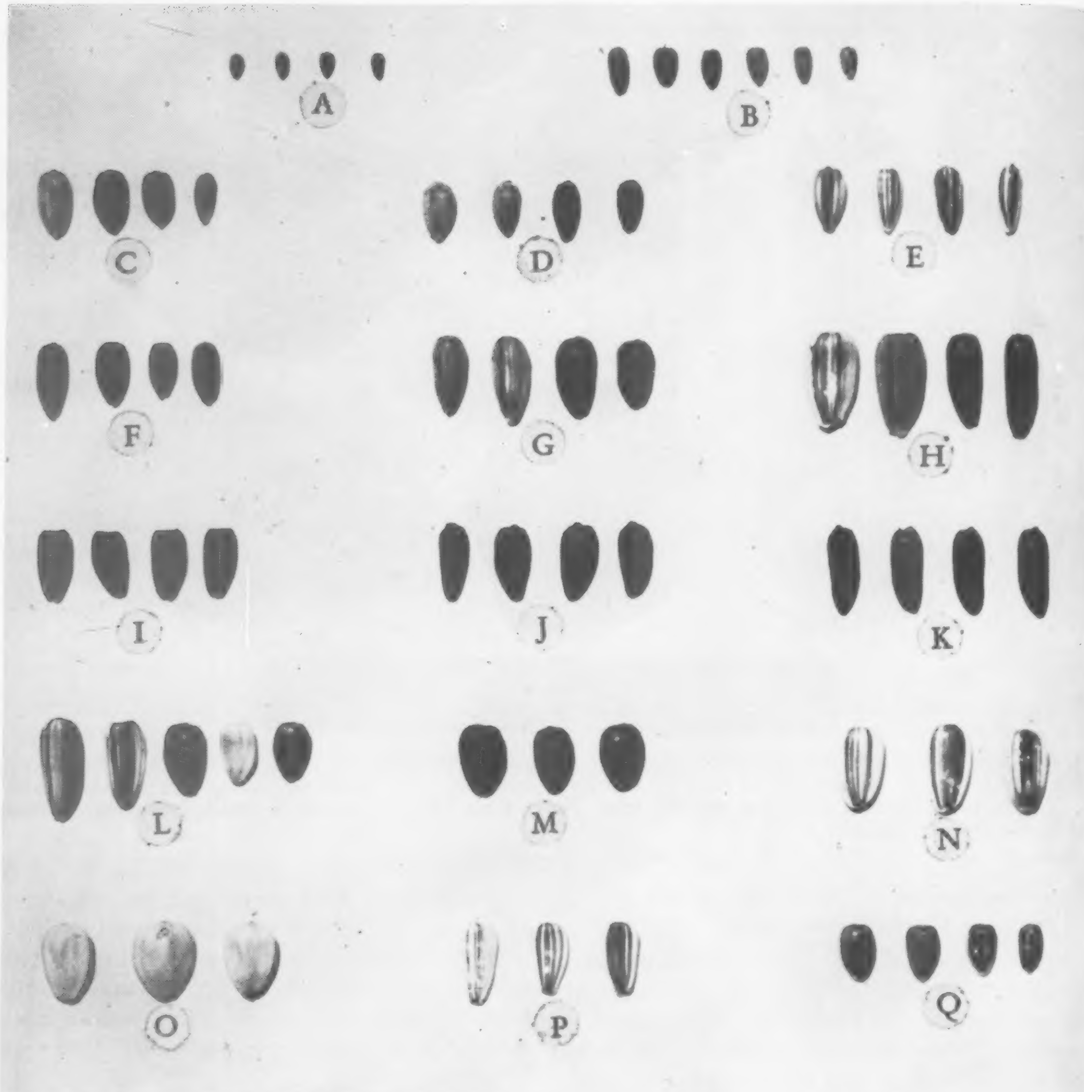

FIGURE 4—Achenes of *Helianthus annuus*. A. the wild sunflower, *H. annuus* ssp. *lenticularis;* B. the weed sunflower, *H. annuus* ssp. *annuus;* C-H. Indian cultivated varieties, *H. annuus* var. *macrocarpus;* I-Q. selected modern cultivated varieties, *H. annuus* var. *macrocarpus.*

to a limited extent on reservations in Ontario and New York State.

The sunflower was also observed among the Algonquin Indians of North Carolina, and Hariot in 1588 wrote "There is also another great herbe . . . about sixe foote in height; the head . . . a spanne in breadth" which was used for making both "a bread and broth." The plant apparently was not cultivated in the southeastern area, but we find references to its cultivation in what is now southern Louisiana and eastern Texas.

Alexander Henry, Thomas Nuttall, and Prince Maximilian all observed the sunflower in cultivation among the Indians on their travels up the Missouri River, but other records of its cultivation in the central United States are lacking, although the greatest use of sunflowers in prehistoric times appears to be centered there. Today the sunflower is still grown by the Hidatsa, Mandan, and Arikara Indians in North Dakota. The sunflowers grown by these Indians are extremely variable and branched forms with rather small achenes

CHRYSANTH. PERVNIANVM.

FIGURE 5—The first drawing of the sunflower in Europe. From the herbal of Dodonaeus (1568). This is clearly the cultivated variety.

are found. These are very similar to the weed sunflower (*H. annuus* ssp. *annuus*) in many respects and could represent a primitive form of the cultivated sunflower or the result of hybridization between weed and cultivated sunflowers.

In the Southwest there are records of the sunflowers among the Zuni, Hopi, and Havasupai, and it is still cultivated in northern Arizona. The sunflower of the Hopi is a late maturing form, characterized by long, narrow, purple achenes. The Hopi used the plant for food, but perhaps the use of the achenes for a purple dye and the rays for a yellow dye was even more important. The Havasupai have the long purple achene similar to the Hopi sunflower but in addition have forms with striped seeds.

The sunflower has been known from Mexico since the sixteenth century, and is grown to a very limited extent among Indians in Northern Mexico today. The Mexican sunflowers are characterized by a slight beak on top of the achene which is unique among cultivated sunflowers today although the beak has also been found on certain prehistoric achenes.

Mangelsdorf and Reeves maintain that the sunflower was not known in Mexico in early times, supporting their claim with the fact that the sunflower is known today only in northern Mexico and known by the name maí'z de teja which "indicates that it was introduced from elsewhere, and after corn was already there." Although the supposition that the sunflower arrived in Mexico after corn was present seems very likely it should be pointed out that the sunflower was also known under the names of "chimalacatl" and "anthilion" which are not derived from the word maize.

The Introduction of the Sunflower Into Europe

The first published record of the sunflower in Europe is in 1568 when the sunflower was illustrated (fig. 5) and described very completely by Dodonaeus. Thereafter there are frequent accounts of the sunflower by the herbalists. According to the descriptions, the first sunflowers introduced into Europe had purple disks, and there was considerable diversity in the achene coloration—black, white, and striped forms are mentioned.

Dodonaeus listed Peru as the native home of the sunflower, and for a time it went under the name *Chrysanthemum Peruvianum.* There is no evidence to substantiate the pre-Colombian occurrence of the sunflower in South America. The assignment of plants to "Peru" in the early herbals cannot always be taken literally, but simply as indications that the plant came from somewhere in the Americas.

The first introduction of the sunflower into Europe probably came from Mexico by way of the Spanish explorers and subsequently from "Virginia" and "Canada" by the French

and English. There can be little doubt that the sunflower went to Europe from somewhere in North America. As previously pointed out there are no records of its cultivation in South America in prehistoric times, and its cultivation there today can be dated as very recent. The wild sunflower extends into northern Mexico which also was the southern limit for the cultivation of the domesticated plant.

The sunflower spread rapidly throughout Europe although at first it was grown chiefly as a curiosity. Sometime previous to the nineteenth century it reached Russia where it became a spectacular success. At the time of its introduction, the Holy Orthodox Church of Russia observed very strict regulations regarding diet during Lent and the days preceding Christmas. Not only meat but many other oil foods were on the prohibited list. However, the sunflower which had recently been introduced was overlooked and as a result the oily seed of the sunflower became a very popular food. Russia soon became the world's foremost producer of sunflowers, a position it occupies to this day.

The sunflower made its way back to the United States in the latter part of the nineteenth century, and it was offered under the name of "Mammoth Russian" or "Giant Russian." It is probable that most sunflowers now in cultivation in this country are derived from Europe rather than directly from the Indians.

Numerous varieties of the cultivated sunflower are now known, although no detailed classification has ever been attempted. De Candolle pointed out that the greatest variability in cultivated plants is generally in the part for which it is cultivated, and we find that the varieties of sunflower differ primarily in the shape, size, and pigmentation of the achenes (fig. 4). The old standard varieties (12′-15′ in height) are being replaced today by semi-dwarf (6′-8′) and dwarf varieties (3′-6′) which can be harvested with modern farm machinery. There are no well defined botanical taxa that can be recognized among the cultivated sunflowers, and there seems to be no valid reason for attempting to assign Latin names to the different cultivated varieties.

Discussions and Conclusions

From the evidence now at hand it is clear that the sunflower was domesticated in temperate North America. It is not possible to reconstruct the definite steps leading to the origin of this plant but the following working hypothesis may be advanced. The wild sunflower (*H. annuus* ssp. *lenticularis*) in remote times became a food plant of the Indians of western North America. In time it became a camp-following weed and was carried into many new areas by the Indians. In the central and eastern United States the new weed became more or less stabilized and the race known as *H. annuus* ssp. *annuus* had its origin. This weed may actually have been brought into cultivation and with the selection of mutants restricting branching and increasing seed size this plant could have developed into the giant, monocephalic plant known today as *H. annuus* var. *macrocarpus*. It is not possible to point to one definite region as the center of origin of the new form but the present distribution of the weed sunflower and the distribution of the archaeological sunflowers strongly suggest the central United States as the place of origin.

The sunflower, then, is unique in having its origin in temperate North America, for the majority of American food plants were brought into domestication in Central or South America. Whether the sunflower was domesticated before these Indians had acquired other cultigens and thus agriculture had an independent origin in temperate North America or whether the sunflower was brought into cultivation after these Indians had acquired the knowledge of agriculture from other peoples is not clear.[3] It may have been that the sunflower was a basic food before the introduction of maize. With the introduction of maize, a most superior food plant, the sunflower lost its dominant position and was kept mainly for its secondary uses as a dye

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[3]Achenes of *Iva*, the marsh elder, have been found among the archaeological remains from the Ozark and Kentucky shelters (2, 6). These achenes are much larger than those of the wild *Iva ciliata* to which they appear related, and it has been suggested that they come from cultivated plants. This plant is not known for any historical Indian group, and it may also be that it disappeared with the arrival of other cultivated plants.

and oil plant. However, as yet there are not enough facts to allow much more than speculation on this interesting subject.

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New England Biological Association Meeting

The New England Biological Association met on March 19, 1955, at the Harvard Blood Preservation Laboratory, Boston, Massachusetts. Dr. Robert Mac Creadie, Assistant Director of the Biological Laboratory and his assistants determined the blood types of those who requested it. A tour of inspection was conducted through the laboratories.

Dr. D. M. Surgenor of the laboratory staff explained the principles and mechanics of blood fractionation. The process was demonstrated and Association members saw the red cells separated from the plasma, looked at platelets, and observed and handled packaged plasma.

All in attendance at this excellent meeting were impressed with the Laboratory's research program, and returned to their respective communities with a feeling of appreciation for "a day well spent."

An Education Directory of Education Associations, Part 4, has been published by the U. S. Department of Health, Education and Welfare, Office of Education. The cost is 30 cents.

Science and English Combine

EMMA FORCE, Biology Teacher
LOIS RAMSTACK, English Teacher
Whitefish Bay High School
Milwaukee, Wisconsin

The combination of two of our major courses was demonstrated recently. Two of our sophomore biology students who were also taking a sophomore speech course drew upon their biology background for the subject matter for a required original dramatization in speech. The presentation was so effective that the skit was selected to be part of an assembly program.

The skit "The Plight of the Amoebae" was written and presented by Dorothea Gother and Sue Shultz. The accompanying illustration was done by Richard Silberman, a student photographer.

A cyclorama was used as a background for staging. A black curtain would be more effective, but a lighter one may be used. The opening of the stage curtains was narrowed as much as possible. The only light was a dark blue spotlight located in the auditorium. An overhead spot could be used with equal effect.

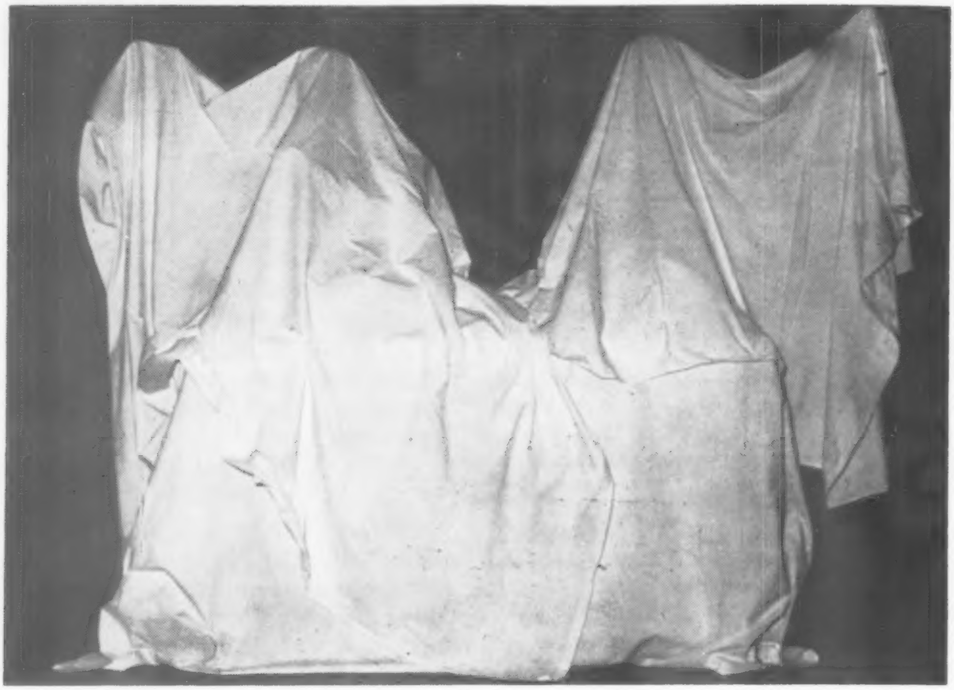
An ordinary schoolroom table served to create the setting. It was draped with white sheets. The girls sat on the table, and they too were draped with white sheets to give the effect of the amoebae. Movement of head and arms simulated action and helped the movement of the skit. A final suggestion might be made about casting. Small but clear girlish voices are more effective in characterization, than boys' voices.

"The Plight of the Amoebae"

1st Amoeba: Oh woe is me! Oh cruel, cruel world!

2nd Amoeba: What's the trouble? It's been wonderful for me.

1st. Amoeba: Food is so scarce lately. I have only one, mind you one, well fed food vacuole to my name. And the rebellious bacteria I just caught in it are still alive and kicking. Not only that but it has an outrageous taste. It's giving me a vacuole-ache.



"Amoeba" about ready to divide.

2nd Amoeba: I have a very tasty one here; I'll give you a tip—I got it over there. Flow over and get one. Try the purple kind. I think they're the best. But if you can't get it, get the pink. I didn't have any, but I think they're awfully pretty. I imagine there's quite a bit left, although those fancy paramecia with cilia are gathering fast.

1st Amoeba: I'd give anything for one of those new streamlined flagella. Just think how fast I could go with one. Why I could be over to the bacteria ten times as fast and leave those paramecia far behind. But some euglena who have them are a real danger. You know those euglena are a crazy mixed-up bunch. They don't even know if they're plant or animal.

2nd Amoeba: I'm simply mad about the shade of green in those chloroplasts. And those red eyespots! Just a while ago I'm sure one of them winked at me. Your ectoplasm looks sort of cloudy. Is it brown algae that does that?

1st Amoeba: Yes, I really should go on a diet. But those brown algae are so good. They taste just like those rare blue-green algae. I've never had such a delicacy, but I've heard tell——. What are you staring at?

2nd Amoeba: I wish I were a paramecium. Just think, cilia, and best of all, two nuclei. You might know it'd be just my luck to be a nondescript amoeba without even a fixed cell membrane.

1st Amoeba: Well, I wouldn't have two nuclei. You know very well that too many cooks spoil the broth. Look at that one over there. What a show off! You'd have to put up with people like that.

2nd Amoeba: Those vorticella are the ones I can't stand. They're so stuck up! They never circulate, just keep to themselves. If you just try to be friendly, they contract before you can so much as say hello.

1st Amoeba: Maybe they're shy. Or maybe the fact that they have to remain in one place gives them an inferiority complex.

2nd Amoeba: Speaking of complexes — It's rumored that we amoebae are rated the very lowest in the whole animal kingdom. What nerve!

1st Amoeba: Oh! Here comes that handsome amoeba, Spike.

2nd Amoeba: I've heard that Spike is parasitic! Can you imagine? I refuse to associate with him. I might just get a bad reputa-

tion. You know you're judged by the company you keep.

1st Amoeba: Have you seen Sam on your journeys? I haven't seen him since homecoming at our alma mater. He was a real solid guy.

2nd Amoeba: Yes, he expected to divide soon. I hope he didn't have any trouble. He probably did though. I heard there were hydra in the vicinity then. Boy, did a hydra do damage to our fair species! My twin was one of those unfortunates. Is he an enormous monster. He eats so much too. Did you see him?

1st Amoeba: No, I've traveled pretty far today and wasn't near there.

2nd Amoeba: Say, what's your native vicinity?

1st Amoeba: I'm from the middle west of the pond. On the way here, I saw the cutest 'lil 'ol amoeba from 'way down south. Talk about an accent, you've never heard anything like it. Say do you belong to the Association for the Advancement of Amoebae? We're having a meeting this afternoon over by the mountain. Why don't you come with me?

2nd Amoeba: Thanks, but I don't think I can. My water vacuole just isn't what it used to be. I wish that once, just once, it would contract at the normal rate of speed. It hurts so when it gets violent. Not only that, but I must remember not to eject a pseudopod here again. I've been running around so fast lately with all the clubs and things, I've practically worn a hole in my cell membrane.

1st Amoeba: I was just wondering if binary fission hurts. I have a feeling I'll be dividing soon, and I'm scared.

2nd Amoeba: Me too. Look at poor Joe over there. He was caught and someone removed his nucleus. I'm afraid he's not long for this world. I hope that doesn't happen to me.

1st Amoeba: Just think what fun it'd be to be twins though. Eh?

2nd Amoeba: Pardon me! I have orders from my nucleus to go over and have some more of that bacteria. Oh! my waistline!

1st Amoeba: I guess I'll be flowing along too. Good-by.——Oh me, life is so complicated.

Books for Biologists

EVOLUTION OF THE VERTEBRATES. Edwin H. Colbert. Professor of Vertebrate Paleontology, Columbia University. 479 pp. $8.95. John Wiley and Sons, Inc. New York 16, New York.

This book attempts to present a very general review of vertebrate evolution, and to show how animals with backbones developed through more than 400 million years of earth history. It is not a book on the principles of evolution although principles are frequently mentioned or discussed in passing. Nor is it a book concerned with the mechanics of evolution as revealed by genetics. As stated above, the book is primarily a survey of the fossil record of backboned animals. Many excellent illustrations, practically all of them new, contribute to the understanding of the text.

ASPECTS OF DEEP SEA BIOLOGY. N. B. Marshall, England. 380 pp. $10.00. Philosophical Library, New York, New York. 1954.

A beautifully illustrated (by the author's wife) book which traces the growth of deep sea biology and gives an integrated account of oceanic life. The book is stimulating, informative, and filled with many fine black and white illustrations as well as colored plates.

The illustrations and text are closely knit together which makes the book understandable to both the scientist and to all with a keen interest in sea life. The author has been engaged in deep sea research for many years and many of the results of his own work are reported in this book.

THE DISCOVERY OF UNICELLULAR LIFE. Excerpts from Communications by Antoni Van Leewenhoek to the Royal Society of London (September 7, 1674 and October 9, 1676). Foreword by A. J. Kluyver. 16 pp. Free. The Chronica Botanica Co., Waltham 54, Massachusetts. 1954.

In 1932, the tercentenary of Leewenhoek's birth, the Royal Netherlands Acadamy of Sciences set up a committee of Dutch scientists to prepare and annotate a new and complete edition of Leewenhoek's writings, the "Collected Letters." Four volumes of this work have now been published. Further information on this monumental undertaking will be found in Dr. A. Schierbeek's "Appeal" on p. 15 of this Chronica Botanica Keepsake. The above excerpts have been reprinted from these four volumes.

A Bibliography of Material On Animal Experimentation is available from the Illinois Society for Medical Research, 951 East 58th Street, Chicago 37, Illinois.

The National Parks - World's Largest Summer School[1]

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The largest summer school in the world . . . It is not California or Columbia or Chicago, nor is it any foreign university. It has a campus of some 25 million acres, a faculty of over 400, and the enrollment last year was nearly 19 million. The campus consists of the 180 federal areas administered by the National Park Service—famed for their scenic, scientific and historic values. The faculty is composed of picked men—mostly professional teachers in high schools and colleges who are fortunate enough to be able to spend their summers as ranger-naturalists and ranger-historians, interpreting these areas to visitors. The student body is composed of those Americans (and foreign visitors as well) who take advantage of the free services offered each summer by the National Park Service. It is not an old school compared to most universities and colleges throughout the country, yet it probably has more alumni than any.

The educational work in the national parks grew out of a demand by the visitors to know something about the wonders they had come to see. Until 1920, most of the guiding, where it was done at all, was done by hotel porters, who were much more interested in amusing their patrons with tall tales of the country than in giving them accurate information. Slowly, the National Park Service realized that a visitor enjoyed his trip more if he knew, for instance, that the Grand Canyon was formed by the cutting action of the Colorado River than if he were told that the great chasm was formed as a result of two Scotchmen looking for a quarter they had dropped.

[1]A paper presented to the National Association of Biology Teachers in joint session with the American Nature Study Society, December 28, 1954, Berkeley, California.

As funds became available the work was taken up in one park after another. Men with special qualifications were given year-round assignments in a number of the parks. They began, sometimes by themselves and sometimes with the aid of a temporary staff during the summer season, to lay the groundwork for the largest summer school in the world. It is doubtful that any of the pioneers in this work—and I count myself as one of them—visualized the potential of the work that was just beginning.

The beginnings were not auspicious. There was little money, practically no equipment, and even less understanding on the part of some National Park Service officials as to just what this new group of "upstarts" had in mind.

At the first, evening talks were given in the lobbies of hotels and lodges and around campfires at the campgrounds. Groups were taken into the field to get firsthand information on trees, animals, flowers, and the geological features. Where possible, small museums were established, as were self-guiding Nature trails and roadside exhibits. The slogan "Learn To Read The Trailside As An Open Book" was adopted and taken seriously by those who participated in the programs.

Through the years, experience and planning have refined and improved the work. In 1925, the annual visitation to Yosemite was 209,166. In 1953, 969,225 persons visited this park. This increase has been reflected throughout the National Park System, and the attendance at the talks and field trips and museums has kept pace. In the early days, it was referred to as the "educational work," but more recently we have substituted the word "interpretation" for "education." If we interpret the phe-

(Continued on page 173)

Utilization of a Marine Environment in the Teaching of Biology[1]

HELEN BUSH BOER
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In recent years interest in the sea and its surroundings as a potential source of materials for the biology classroom and laboratory has received more continuous attention. However, even in coastal areas where the tidal changes determine integral but subtle behavior responses in the lives of the citizens, there is, unfortunately, a consistent lack of organized understanding and study of the sea and its abounding plant and animal life.

High school biology teachers of today are progressively reaching outside of the stereotyped pages of their textbooks to the world beside them. Today the outmoded "assign-study-recite" daily lesson plan has been superseded by a more vital approach. Biology teachers are seen embracing a dramatic living philosophy to encompass the most thrilling of all aspects of human study—the study of life!

How appropriate it is to turn to the sea and its environment for a beginning realization of early life and biological development. The oceans taken together cover almost seventy-two per cent of the earth's surface, or approximately one hundred forty million square miles. The combined volume of these waters is fourteen times that of all the land that is found above sea level. Considering such an expanse, is it not provocative that so much of man's time is occupied with study of the land?

From earliest years, children have had concentrated geography lessons on countries with emphasis on physical topography and the aboriginal inhabitants. They have named the surrounding bodies of water and been able to point to them on maps, but beyond such a cursory and limited experience the lesson usually ends. It is not surprising then to discover that most students are anxious and eager to satisfy their long aroused curiosity concerning the wide and deep unknown regions of "our world."

The alert biology teacher, planning a course of study based on pupil interest can hardly overlook the possibilities of development in some phase of the marine environment. There is an individual appeal to such a unit of study no matter what the intellectual quotient of the student. For just as the sea nourishes creatures of the most primitive types to the most highly advanced nervous systems of marine mammals, so the sea environment provides a stimulus for study for every mentality. In fact, some of the slower students make better elementary marine biologists than their more apt brothers who in haste to "learn more" rush ahead and lose some valuable lessons that only patience and thoroughness can teach. Difficult adolescents who approach the study of biology with indifference and a certain subconscious dread, react favorably and often with considerable passionate interest to the study of the unknown abysses of the unfathomable sea.

Especially fortunate are those teachers who live within driving distance of the ocean and can discover "first hand" marine plant and animal life and habitat with their students. There is no greater thrill to the budding scientist than finding, feeling, and formulating ideas and concepts about life within the environment of the sea. However, those who do not have the privilege of proximity need not be discouraged in utilizing the marine environment in their teaching. For with the aid of audio-visual devices, the sea and its dwellers may be brought into every classroom.

Give the students an opportunity to aid in building a file of pictures and articles. Soon folders set aside for this purpose will be bulging, and next year's classes will have a good start although they will miss the fun of an initial collection. Popular magazines have vitalized their pages with pictures and descriptions of the sea and its inhabitants. Hollywood, never far behind national concerns, has pro-

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[1]Presented at a joint meeting of the Florida Association of Science Teachers and the National Association of Biology Teachers as part of the The American Institute of Biological Sciences program, Gainesville, Florida, September, 1954.

duced an increasing number of authentic films dealing with life in the sea. There is hardly a high school student today who does not know of the production of Rachel Carson's *The Sea Around Us* or who hasn't read at least the "Reader's Digest" condensation of the book.

A study-unit based on the sea and its environment is particularly adapted to integration with various subject fields. In almost every biology textbook there is a unit which explains the classification of animals into their respective phyla. Ten only are usually considered at the high school level. This may be illustrated very well by various sea creatures ranging from single celled protozoans to the porifera, the coelenterates, ctenophores, nematodes, annelids, echinoderms, (the arthropods are primarily land dwellers except for the crustaceans), the molluscs, and more consideration is given chordates on land rather than on sea. A golden opportunity is there to augment the too often dry memorization of animal classification into the most fascinating and remembered study of the entire course in biology—and yet keep within the confines of the present organized curriculum.

Science teachers could profitably work in closer cooperation with teachers in the fine arts—literature, art, and music to win more advocates to both fields. The ideology enjendered by too many sensitive young women that science is sterile and unappealing would vanish if they could be broadened to visualize the interplay and dependence all study fields have on biology and science as a whole.

More specifically—how can the study of marine creatures be related to other subjects? There is much in literature that pertains to sea lore both in prose and poetry. Sea chanties and ballads provide pleasant relaxation in classes of literature as well as in music. What youngster does not enjoy the raucous strains of "Blow the Man Down?" What individual does not thrill to the esthetic emotions produced upon listening quietly to Debussy's majestic portrayal of the sea in the symphonic work, "LaMer?"

English teachers have long complained that students of science are oblivious to oral and written English. How easy and pleasant it would be to motivate both classes through closer integration! What far reaching effects such a course of action would have.

Art teachers are perhaps the most eager of all others in the teaching profession to cooperate outside their particular field. A biology teacher developing a unit on sea life would profit immensely by consulting with the art instructor and working together with her. The young biologist soon feels his dependence upon art for drawings in the laboratory. In biology a drawing can often express what verbalizations fail to do. Art in biology must not be limited to pen or pencil sketching, for other media are often better suited for more adequate portrayals.

To those who become interested in the science of oceanography, physics and mathematics are essential pre-requisites.

Repeatedly it has been suggested that the unit approach is the best method for groups to study marine life as it provides the means for creative teaching as well as creative student participation. To further supplement such a unit, field trips to museums, marine laboratories, or the seashore should not be omitted. Mimeographed sheets with expected outcomes, collections to make, and a check list of definite organisms aid in keeping minds from straying.

Within the unit, films should be shown, experienced speakers if they are available invited to participate, and there should be interspersed some teacher lectures. Toward the end of the unit teacher and students together should evaluate their progress toward accomplishing the set of objectives set forth at the beginning. On the high school level, broad concepts with their ensuing development of interest and appreciations is the real goal. Leisure time activities related to the subject show the final success or failure of the unit.

In conclusion, it is hoped that all biology teachers in particular will heed the mariner's prayer to be the medium through which more individuals may be brought to an understanding of the surrounding seas with their abundant plant and animal life. The haunting words of Ralph Waldo Emerson in his poem "Seashore" reecho an unmet challenge:

"I heard, or seemed to hear, the chiding Sea
Say? Pilgrim, why so late and slow to come?
Am I not always here?"

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THE NATIONAL PARKS

(Continued from page 170)

nomena of the national parks, the education takes care of itself.

At present, there is a permanent staff of 127 augmented by some 300 seasonal employees. One hundred and seven museums are scattered throughout the System, as well as a good many Nature trails and roadside exhibits. Records are not available as to the number of persons served during those early years, but last year 18,901,244 persons participated in the interpretive program.

The value of the interpretive work is like Portia's quality of mercy—twice blessed. It benefits those who participate by giving them a richer background and deeper understanding not only of Nature but of the national parks and national monuments. And it benefits the parks themselves, for each year, through this understanding and appreciation, it adds thousands to the ranks of those who feel a personal interest and pride in the National Park System.

Have You Heard?

. . . . The mounting and exhibiting of illustrative material from periodicals has been facilitated through the use of a newly developed rubber-coated acetate, which lifts only the ink from the printed page, making a transparency. This method, which makes possible the enlargement of small illustrations, is described in the article, "Transparencies from the Printed Page," by Harvey Frye and Edward McMahon, in the February issue of EDUCATIONAL SCREEN.

. . . . High school and college biology instructors are welcoming three new aids to the laboratory study of animals. Prepared by Albert Wolfson and Arnold Ryan, they are the 6½ x 9½" books, THE EARTHWORM, THE FROG, and THE HUMAN. In each book, following a condensed text, are excellent color drawings printed on eight acetate pages, which show the layer-by-layer dissection of the animal in ventral-to-dorsal sequence. The reverse side of each page shows the dorsal view of the layer depicted on the front side. Relationships of parts to each other are seen by overlaying the dissection pages. Dissections of the earthworm are enlarged to ten times life size; those of the frog are life size; and those of the human are reduced to one-fourth life size. The relatively small size of the pages tends to encourage use of the books with small laboratory groups, which should profit immeasurably from these guides. Row, Peterson and Company, 104 South Lexington Avenue, White Plains, New York; or 1911 Ridge Avenue, Evanston, Illinois.

. . . . A new direct measuring microscope enables the user to obtain accurate readings of dimensions, radii, angles and holes, even where irregular surfaces present problems. Featuring versatility and an erect image, this instrument has been produced by the Edmund Scientific Corporation, 101 E. Gloucester Pike, Barrington, New Jersey.

Recent A-V Releases

PRINCIPLES OF BIOLOGY, SET NO. I. Six black and white filmstrips, illustrating and explaining basic concepts of biological science. High school and college. Young America Films, Inc., 18 East 41st Street, New York 17, New York.

ANIMAL LIFE AT LOW TIDE. 11 min., sd., color. Life at the bottom of tidal flats, featuring starfish, sea worms, snails, limpets, sea anemones and others. Natural protective means and food getting are emphasized. The molting of hermit crabs is shown. Intermediate grades—high school. Pat Dowling Pictures, 1056 S. Robertson Boulevard, Los Angeles 35, California.

AQUARIUM WONDERLAND. 10 min., sd., color. Establishing and maintaining an aquarium; observation of life processes of fish and of the interdependence of plants and animals. Elementary—junior high. Pat Dowling Pictures, 1056 S. Robertson Boulevard, Los Angeles 35, California.

LIVING BIRD. 13 min., sd., color. The biology of birds, emphasizing the senses, and including also flight, bill adaptations, courtship and nesting. Social behavior of the cowbird. Intermediate—high school. Murl Deusing Film Productions, 5427 W. Howard, Milwaukee 14, Wisconson.

ANIMALS IN SPRING. 11 min., sd., color. Activities of the frog, turtle, fish, bird and caterpillar through the spring; emphasis upon pupil observations of new life and nesting habits. Elementary—junior high. Encyclopedia Brittanica Films, 1123 Central Avenue, Wilmette, Illinois.

ANIMALS IN SUMMER. 10 min., sd., color. Activities and struggle for survival of frogs, fish, snakes, moths, bears, squirrels, foxes. Elementary—junior high. Encyclopedia Brittanica Films.

THE ELECTRIC EEL. 12 min., sd., color. Defensive mechanisms, food-getting equipment and other biological activities of the electric eel in relation to its physical makeup. Upper elementary—college. Moody Institute of Science, Educational Film Division, 11428 Santa Monica Boulevard, West Los Angeles 25, California.

BLIND AS A BAT. 7 min., sd., color. Controlled laboratory experiments demonstrate the ability of a bat to fly successfully in total darkness. Elementary — high school. Moody Institute of Science.

Emery L. Will
State University Teachers College
Oneonta, New York

Biology in the News

BROTHER H. CHARLES, F.S.C.
St. Mary's College
Winona, Minnesota

SCIENCE TACKLES RADIATION PERIL, *Life*, March 21, 1955, pp. 32-39.

What can radiation do to living things? What effects can be expected from the fallout from H bombs and other atomic bombs? Will man be affected in his heredity? This article presents a few facts and raises many questions.

HOW TO KEEP YOUR FAMILY YOUNG, Dr. Thomas K. Cureton, Jr., with Bob Allison, *Redbook*, April 1955, pp. 30-31, 90-91.

A leading expert answers your 16 biggest questions on how to help your body stay strong and healthy.

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HOW TO BE A HIGH SCHOOL BEAUTY, Ruth Martin, *Good Housekeeping*, April 1955, pp. 121-124.

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ARE WE SCARING OURSELVES TO DEATH? Dorothy Thompson, *Ladies Home Journal*, April 1955, pp. 11-12.

Are we becoming neurotic over the dangers of dying from this or that disease? The author cites research which has resulted in an increase in life expectancy and joy of living. The article cultivates confidence rather than fear.

BEST WAY TO KILL EVERY BUG, *Country Gentleman*, April 1955, pp. 40-42, 134-135.

Illustrations in color of common farm animals and plants and the insect pests which destroy them. The proper insecticide and how and when to use it is given for each of the pests.